Feature article from Watershed Protection Techniques. 3(2): 647-656

The Benefits of Better Site Design in Commercial Development

Modern commercial development is dominated by the parking lot. Indeed, as much as half of the entire surface area of a typical office park or shopping center is devoted to parking. No one has ever stepped up to claim that they invented the parking lot, and their reluctance is understandable: the parking lot is a prime habitat for the car and not much else.

From an environmental standpoint, parking lots rank among the most harmful land uses in any watershed. Parking lots not only collect pollutants that are deposited from the atmosphere, but also accumulate pollutants that leak, drip or wear off cars. Researchers have found that parking lot runoff can have extremely high concentrations of nutrients, trace metals and hydrocarbons. Parking lots also influence the local air and stream temperatures. In the summer months, pavement temperatures can exceed 120 degrees Fahrenheit, which in turn increases local air temperatures five to 10 degrees compared to a shaded forest. Parking lots can also exacerbate smog problems, as parked cars emit greater levels of smog precursors under extreme heat island conditions (Scott *et al*., 1999).

Perhaps the greatest environmental impact of parking lots is hydrological in nature. Simply put, there is no other kind of surface in a watershed that produces more runoff and delivers it faster than a parking lot. When this runoff is discharged into a headwater stream, its great erosive power steadily degrades the quality of downstream habitats, unless exceptionally sophisticated stormwater practices are installed.

Is it possible to design a better parking lot? At first glance, there seems to be little opportunity to incorporate better site design into parking lots. However, the better site design techniques described earlier in this issue suggest a key design strategy: *work to incrementally shrink the surface area of the parking lots and then use the space saved to integrate functional landscaping and better stormwater treatment within the parking lot.* Through a series of relatively minor design adjustments, it is possible to reduce the surface area of parking lots by five to 20%. These design adjustments include curbing excess parking, incrementally reducing parking demand ratios, providing credits for mass transit, shrinking stall sizes, narrowing drive aisles, and using grid pavers for spillover parking areas.

In this article, we examine some of the benefits of employing better site design as they apply to commercial development. As with the residential redesign, this analysis also uses the Simplified Urban Nutrient Output Model (SUNOM) to compare actual commercial development sites constructed in the 1990s with the same sites redesigned utilizing better site design techniques. The two commercial developments analyzed include a retail shopping center and a commercial office park.

Our fairly conservative approach to parking lot redesign is intended to reflect realistic opportunities in a suburban setting. For example, we did not utilize shared parking, porous pavement, or structured parking in any of the redesigns, although each of these techniques is very effective. Nor did we reduce the basic footprint or size of the buildings in either scenario, although smaller "boxes" may well have been more appropriate for the zoning. Instead, our basic approach was to make a series of relatively modest changes in parking lot design to shrink parking lot area, and then implement better landscaping and stormwater treatment measures within the saved space.

This article reports on the potential benefits of parking lot redesign in terms of reduced runoff, pollutant export and development costs. It also reviews the initial experience of communities that are experimenting with new and innovative parking lot designs, and concludes with some implications for both the engineer and watershed manager.

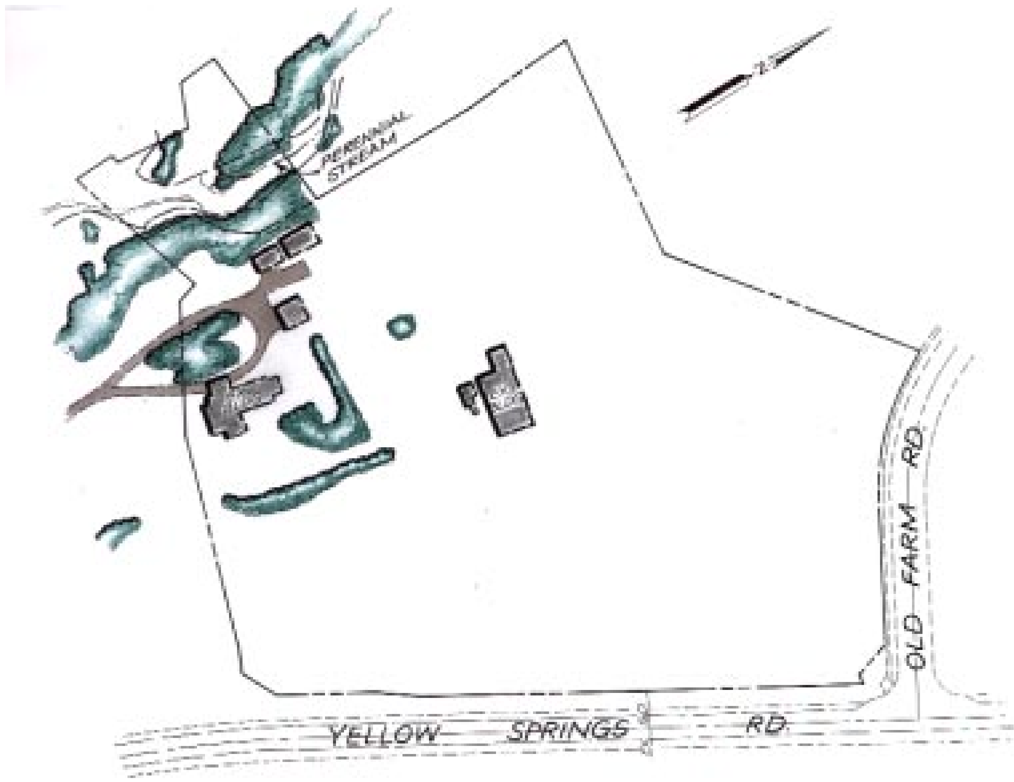

Figure 1: Predevelopment Conditions at the Old Farm Shopping Center Site

Redesign of the Old Farm Shopping Center

The undeveloped Old Farm shopping center, located in the City of Frederick, Maryland, was primarily meadow, with some shrubby forest and a few farm buildings. Bordered by two major arterial roads and served by existing public water and sewer, the site was a prime candidate for commercial development (Figure 1).

Construction of the shopping center site parcel commenced in 1992. The 9.3 acre site is a typical suburban "strip" shopping center with two large retail stores, other retail space, a gas station and a drive-in bank (Figure 2). In terms of surface cover, the shopping center devoted 50% of its total area for parking, as compared to 16% for the actual footprint of the retail buildings. Another 24% of the surface area was devoted to landscaping or stormwater treatment. Less than 10% natural cover was retained on the site, and part of the project encroached on the 100-year floodplain and the stream buffer. The entire site was mass graded during construction. The basic layout was designed to accommodate the car, with generous parking located in front of the stores. The parking lot design provided 5.2 full-size stalls per 1,000 square feet (sf) of retail space, which exceeded the already generous local parking requirement of five spaces per 1,000 sf. According to the most recent national parking research, only 4.0 to 4.5 spaces are needed to serve shopping centers (ULI, 1999).

The stormwater treatment system at Old Farm consisted of an infiltration basin located near the rear of the shopping center that captured runoff from about a third of the site, and three oil grit separators that provide some treatment for the remaining two-thirds of the site. After discharging from the oil/grit separators, runoff traveled through a series of storm drains that extended along the road and eventually discharged to the stream (albeit without detention of any kind). It should be noted that recent performance monitoring has shown that oil grit separators have little or no pollutant removal capability (see articles 119 and 120).

The Redesigned Old Farm Shopping Center

The Old Farm shopping center was redesigned using a "U-shaped" layout that maintained the same amount of gross floor area, but sharply reduced the site area devoted to parking (Figure 3). The new design reduced walking distances, encouraged pedestrian use, and created a more intimate shopping experience. Parking dropped from 50% of the total site area to 38%, primarily because the parking demand ratio was reduced from 5.2 spaces to 4.4 spaces per 1,000 sf of retail area.

The rationale for the lower parking demand was justified in two ways. First, no extra parking spaces were allowed beyond those required by the locality. Second,

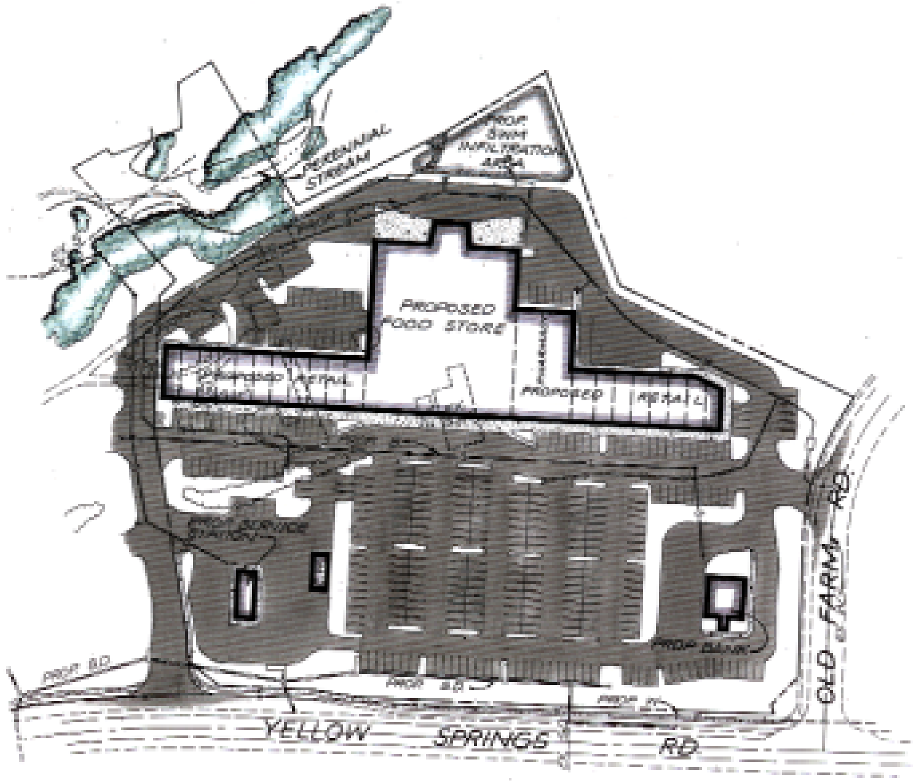

Figure 2: The Conventional Design of the Old Farm Shopping Center

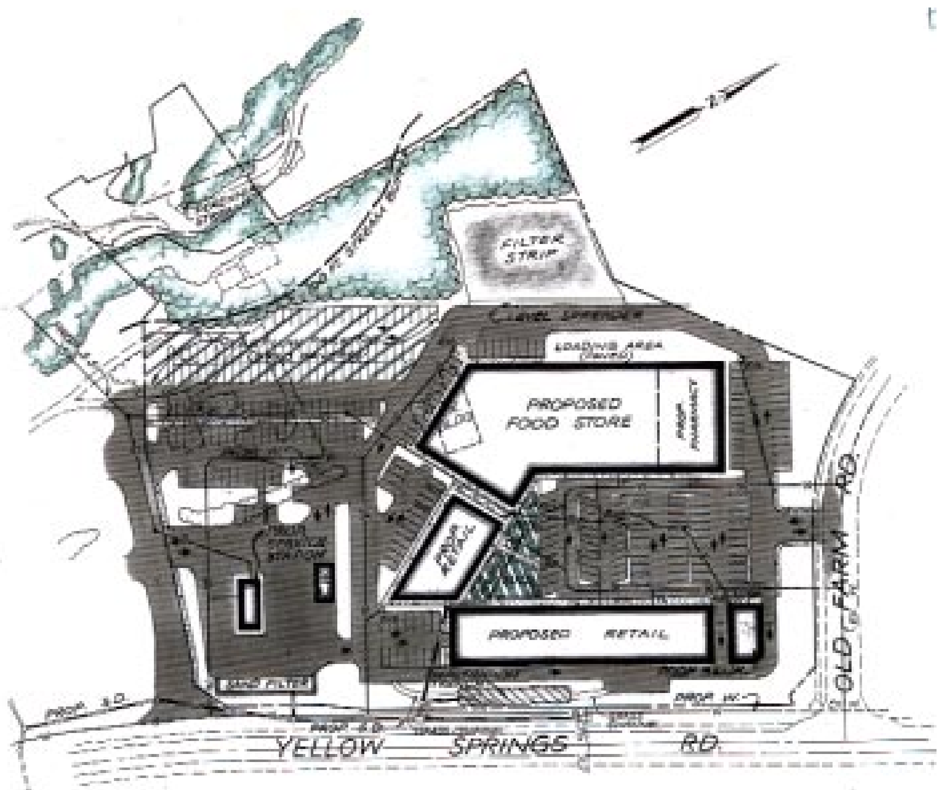

Figure 3: The Innovative Design of the Old Farm Shopping Center

Table 1: Hydrology of the Old Farm Shopping Center Case Study				
		Pre-Developed	Conventional Parking Lot	Innovative Parking Lot
Runoff (inches/yr)	no practice	2.6	24.5	20.6
	practices		18.1	15.1
Infiltration (inches/yr)	no practice	11.8	2.7	3.4
	Practices		9.1	8.9

the existing parking demand ratio was reduced by about 15% to reflect actual parking demand more accurately. As a result, the total number of parking spaces dropped from 343 to 291. In addition, 17% of the parking stalls were designed for compact cars, which require slightly smaller stalls than standard full-sized spaces. Taken together, these changes eliminated slightly more than one acre of parking area, which provided enough space to design a more effective landscaping and stormwater treatment system.

Several parking lot islands were increased in size and converted into bioretention areas to treat stormwater. Other elements of the stormwater treatment system included a sand filter, an infiltration trench, and a filter strip. Furthermore, 25% of the entire parking area was designated for "spillover parking," and grid pavers were used rather than normal paving materials. The grid pavers helped store the first few tenths of an inch of rainfall that would have otherwise run off the parking lot (ICPI, 2000). Lastly, the redesign enabled reforestation and greater protection of the buffer along the stream that runs along the edge of the property. As a result, the proportion of natural cover at the site climbed from 7% to 19% as a result of the parking lot redesign.

Comparative Hydrology at the Old Farm Shopping Center

As expected, the construction of the original shopping center dramatically changed the hydrology of the site (Table 1). The increase in impervious cover from 1% to more than 70% increased annual runoff volume by a factor of nine. The infiltration basin used in the original design helped put some runoff back into the ground, but even so, annual runoff was seven times greater than the pre-development condition. The redesigned parking lot, by virtue of its lower impervious cover and improved stormwater practices, produced about 20% less runoff than the original design. Nevertheless, the stormwater practices at the redesigned parking lot were not able to match the pre-development hydrology.

Comparative Nutrient Output from the Old Farm Shopping Center

The conversion of the meadow into a shopping center greatly increased nutrient export from the site; the SUNOM model indicated that annual phosphorus and nitrogen export would increase tenfold as a result of the development (see Figure 4). Nutrient export from the shopping center was dominated by stormwater runoff, as the model indicated that stormwater runoff contributed about 95% of the annual nutrient export from the site. Nutrient loads were not greatly reduced by the infiltration basin or oil/grit separators that were installed at the conventional parking lot. Nutrient export was still projected to be eight to 10 times higher than pre-development conditions, even after these stormwater treatment practices were installed.

In contrast, the redesigned parking lot sharply reduced nutrient export (Figure 4). In fact, the redesigned parking lot *without* stormwater practices produced about the same nutrient load as the conventional parking lot *with* stormwater practices. This reduction was a direct result of the lower impervious cover associated with the redesigned parking lot. When the redesigned parking lot was combined with more sophisticated stormwater practices (i.e., bioretention, sand filter, infiltration trench and filter strip), the total nutrient export was half that of the conventional parking lot with stormwater practices. It is interesting to note, however, that this load was still about five times higher than that produced by the meadow prior to development.

Comparative Cost to Develop the Old Farm Shopping Center

The cost to develop the redesigned parking lot was marginally lower than the cost for the conventional parking lot — about 5%. Considerable cost savings were realized due to less paving, shorter sidewalks, and fewer curbs and gutters, but these savings were largely offset by added costs for improved stormwater practices, landscaping and grid pavers. Overall, the estimated cost to build the conventional parking lot was $782,500, compared to $746,270 for the redesigned parking lot. The extent of potential cost savings depends heavily on the level of sophistication of the original stormwater treatment system. In this case, the unsophisticated stormwater practices used in the conventional parking design were fairly inexpensive, but were also not effective in removing nutrients.

Summary

Figure 5 summarizes the redesign analysis of the Old Farm Shopping Center. The redesigned parking lot resulted in less impervious cover, stormwater runoff, and nutrient export for a slightly lower development cost than the conventional design.

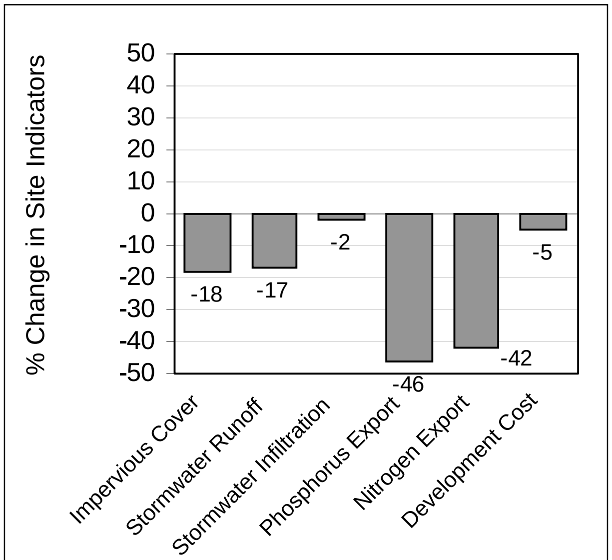

Figure 5: Percentage Change in Key Site Indicators From a Conventional Design of the Old Farm Shopping Center to an Innovative Design, Both With Stormwater Practices

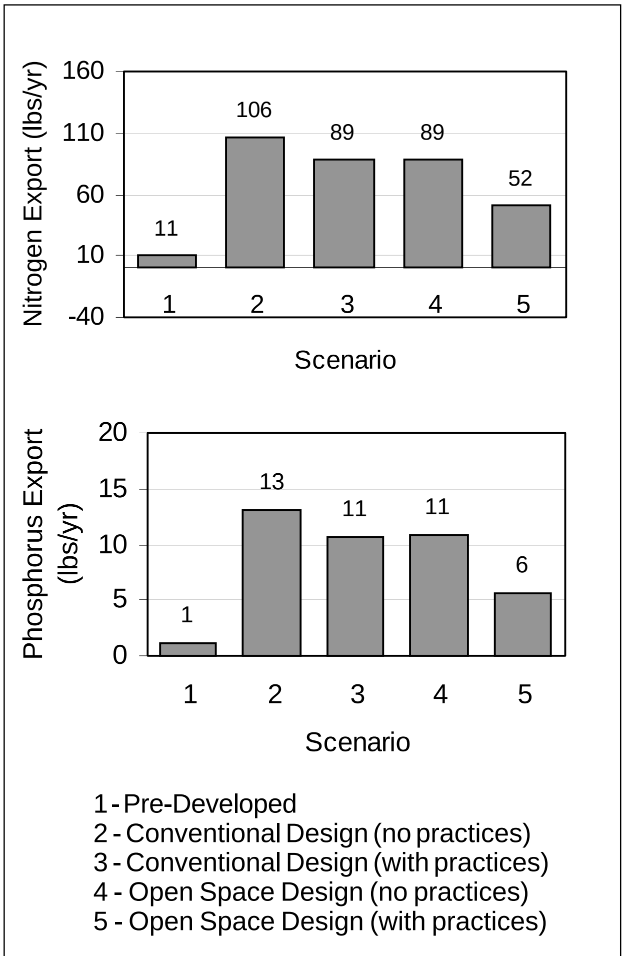

Figure 4: Annual Nitrogen and Phosphorus Export in Each Old Farm Shopping Center Development Scenario

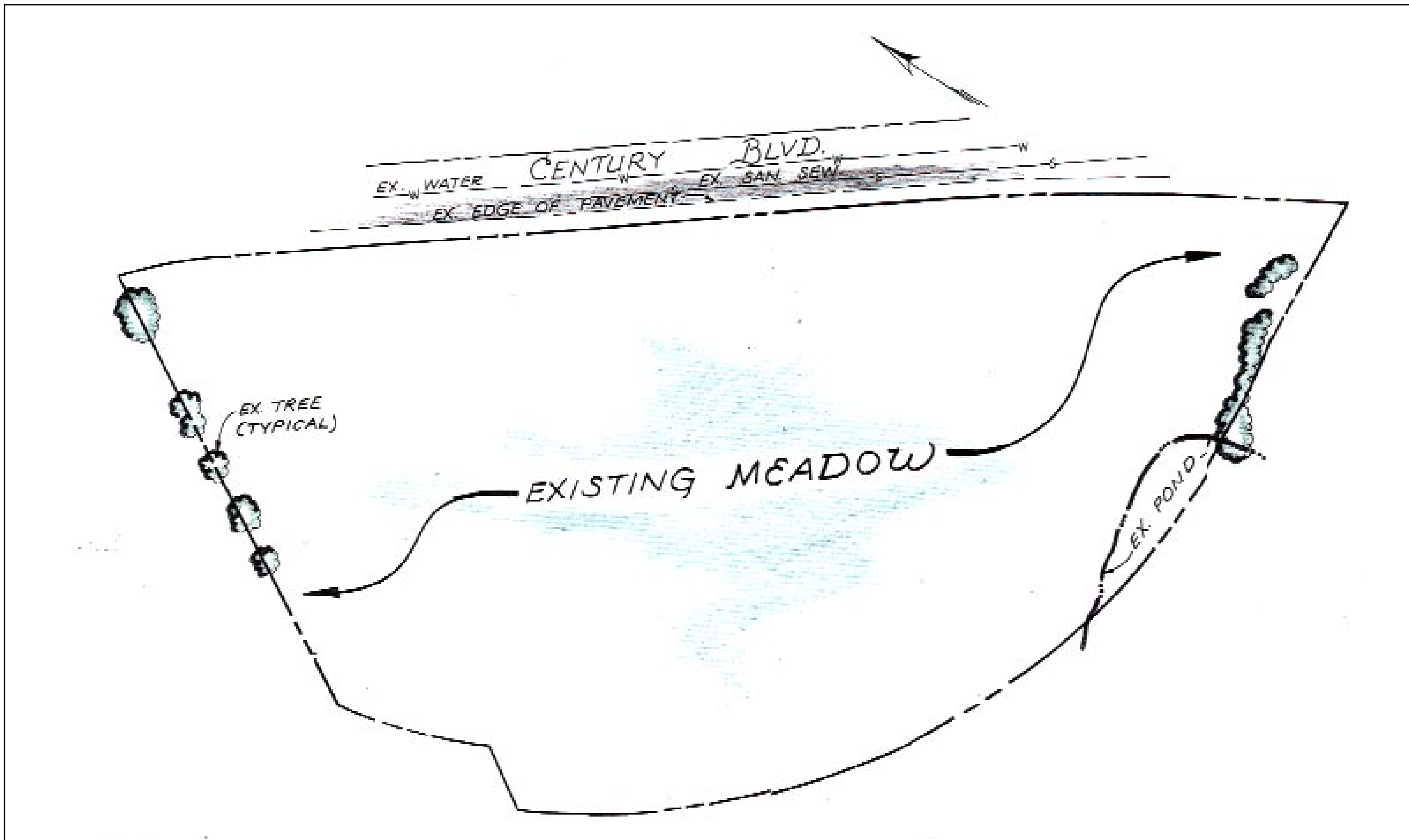

Figure 6: Predevelopment Conditions at the 270 Corporate Office Park Site

Redesigning the 270 Corporate Office Park

The second case study involved the redesign of a typical suburban office park. The 12.8 acre parcel is located in Germantown, Maryland in the mildly sloping terrain of the Piedmont (Figure 6). The existing cover at the site was almost entirely meadow, except for a few trees and an old farm pond that bisected the property boundary. No wetlands or other sensitive natural features were evident on the site. The site was zoned for office development, and existing infrastructure made it an attractive candidate for development. An existing network of public water and sewer, electric, gas, and other utilities ran along the frontage of a large arterial road.

The layout of the conventional suburban office park design is depicted in Figure 7. The project included a pair of five-story office buildings, surrounded by a sea of parking. Over half (52%) of the surface cover at the office park was devoted to parking, as compared to only 11% for actual footprint of the office building. Most of the remainder of the site was utilized for landscaping, stormwater treatment or turf. Only 2% of the natural cover was retained on the site, and nearly all of the parcel was mass graded during construction.

As with many suburban office parks, the location of the building and parking were primarily oriented toward the car. The parking lot was sized using a parking demand ratio of 3.1 spaces per 1,000 sf of building, which slightly exceeded the minimum parking requirements of the locality. As a result, the parking lot created room for 745 standard stalls, along with 33 larger stalls for vans and disabled access. The parking bays also featured roomy aisles between the stalls (24 feet wide). The design was intended to provide some amenities for the office workers, including a short path system between buildings, an ornamental stormwater pond, and some landscaping in required setbacks and parking islands.

The conventional design featured the classic "pipe and pond" approach to stormwater management. Parking lot runoff was initially collected by a curb and gutter system that sent runoff into underground storm drain pipes that, in turn, discharged into two very small wet ponds. Each pond served roughly half of the site and was expected to have a reasonably good capability to remove nutrients.

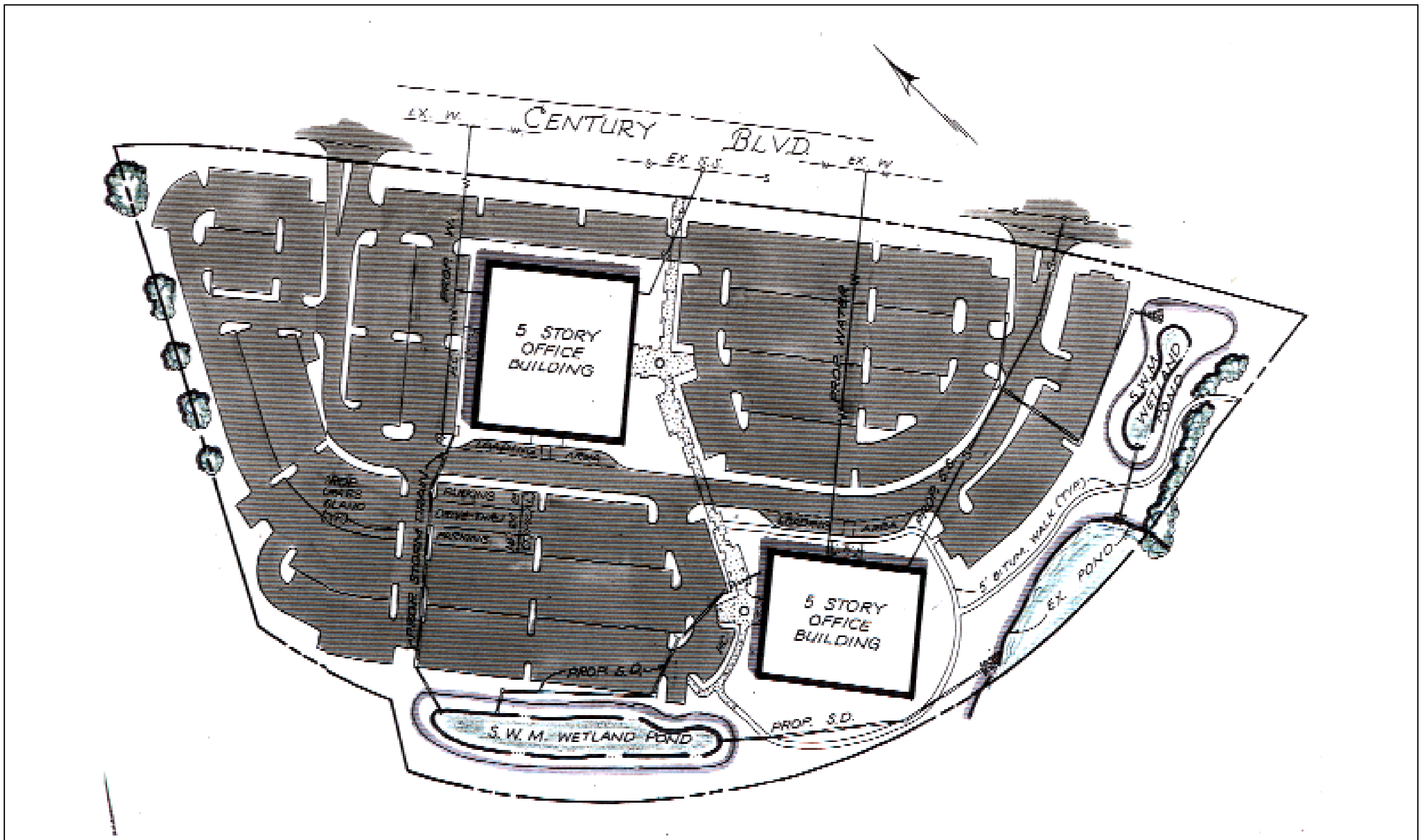

Figure 7: The Conventional Design of the 270 Corporate Office Park

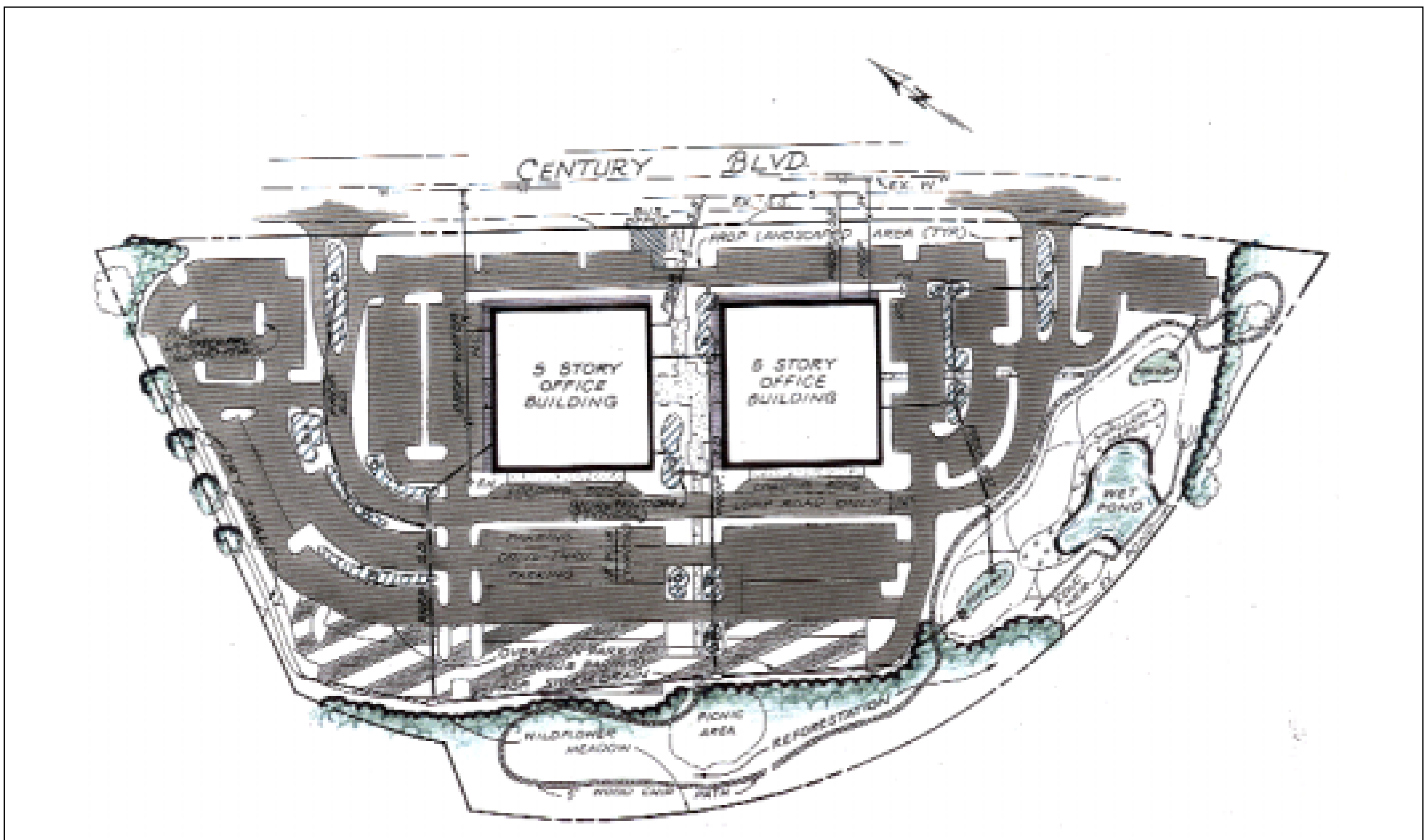

Figure 8: The Innovative Design of the 270 Corporate Office Park

The Redesigned 270 Corporate Office Park

The redesigned site employed a number of techniques to minimize impervious cover and improve stormwater treatment (Figure 8). The office park featured the same amount of office space, but the two office towers were situated closer to the road to shorten utility extensions, and pedestrian access to a bus stop was provided to encourage the use of public transportation.

The key strategy employed in the redesign was to incrementally reduce the size of the parking lot, and this was achieved in five ways. First, no excess parking spaces were allowed over those required by the local parking demand ratio. Second, the local parking demand ratio was reduced by 8% to reflect actual parking demand. Third, the parking demand ratio was reduced by another 10% to reflect the proximity to the bus stop. Fourth, the size of approximately 20% of all parking stalls was downsized to accommodate compact cars. Lastly, drive aisles in many parking bays were reduced from 24 feet in width to 20 feet. Combined, these measures reduced the total parking lot area by nearly 30%, or about two acres. Once again, the savings in paving gave the designer more room to integrate landscaping with more effective stormwater treatment.

For example, larger landscaping islands were installed in the parking lot to plant shade trees, and some of these areas were also converted into bioretention areas to treat stormwater. A dry swale was used to treat stormwater within a landscaped setback area in another part of the site. About 15% of the lot was designated for spillover parking, and grid pavers were used to attenuate runoff in this area. The basic stormwater management goal was to attenuate, treat, or recharge as much runoff from smaller storms as possible in the parking lot itself. Runoff from larger storms was treated in a wet detention pond near the outlet of the property.

As a result of the redesign, roughly 14% of the office park was either retained in natural land cover or reforested (compared to 2% under the conventional design). This green space, combined with the water features and a walking path, created a more tranquil environment for office workers. Overall, the total impervious area associated with the redesigned office park dropped from 68% to 53%.

Comparative Hydrology for the 270 Corporate Center Office Park

The hydrological story was much the same for the 270 Corporate Center as for the shopping center. Construction of the conventional design sharply increased annual runoff volumes and decreased infiltration (Table 2). Runoff did not increase as much in the redesigned parking lot, primarily because its impervious cover was much lower. Annual runoff volumes were 21% lower in the redesigned parking lot compared to the conventional design, and infiltration volumes were 42% higher. Despite these improvements, the redesigned parking lot was unable to mimic the hydrologic conditions prior to development.

Nutrient Output at the 270 Corporate Center Office Park

As expected, the conversion of the meadow into an office park greatly increased nutrient export. Annual phosphorus and nitrogen export increased roughly tenfold, according to the SUNOM model (Figure 9). As with the shopping center, stormwater runoff was found to generate about 95% of the annual nutrient export from the site. The two wet ponds were reasonably effective in removing nutrients at the conventional office park, but still resulted in nutrient export that was seven to eight times higher than pre-development conditions. In contrast, the redesigned parking lot sharply reduced nutrient export (Figure 9). The combination of lower impervious cover and more effective stormwater practices reduced nutrient export by about 40 to 50%, when compared to the conventional parking lot design *with* stormwater practices.

Table 2: Hydrology of the 270 Corporate Office Park Case Study

Hydrologic Factor	Pre-Developed	Conventional Parking Lot	Redesigned Parking Lot
Runoff (inches/yr)	2.7	23.9	18.9
Infiltration (inches/yr)	11.8	2.6	3.7

Note: no change in the annual volume of runoff or infiltration was calculated as a result of the stormwater practices installed at either the conventional or redesigned parking lot.

Comparative Cost to Develop the 270 Corporate Office Park

The cost to develop the redesigned office park was approximately the same as the cost to develop the conventional office park, although the component costs were somewhat different. Less was spent on paving, sidewalks and utility pipes, but these savings were largely offset by higher costs for improved stormwater treatment practices, landscaping, grid pavers and curiously, curbs and gutters (the higher cost for this last item was due to the wider parking islands used for bioretention areas). Overall, the estimated cost to build the conventional parking lot was $948,900, compared to $921,200 for the redesigned parking lot.

Overall Summary: Office Park Redesign

The redesigned parking lot at the 270 Corporate Office Park resulted in less impervious cover, stormwater runoff, and nutrient export for about the same development cost as the conventional design. The results are summarized in Figure 10.

The Limits and Potential of Parking Lot Redesign

To our knowledge, no one has yet tried to quantify the potential economic and environmental benefits of better parking lot design at new commercial developments. This initial analysis provides compelling evidence that better site design is an important, if not indispensable, tool for managing the quantity and quality of stormwater runoff from parking lots.

In each of the case studies, the redesigned parking lot resulted in less impervious cover, stormwater runoff, and nutrient export for about the same or even slightly lower cost than the conventional design. Taken together, better site design techniques reduced impervious cover by at least 15% in each case. While this is an impressive reduction, about half of each site remained impervious after the redesign. Perhaps the most critical benefit of each redesign was that it created more room to locate more effective stormwater treatment practices. When smaller parking lots were combined with better stormwater practices, the resulting nutrient export was almost half that of a conventional parking lot.

In each case study, the critical ingredient was an incremental reduction in the local parking demand ratio. Without this capability to shrink the surface area devoted to parking, designers have little ability to devise the more sophisticated stormwater treatment and landscaping systems that can help mitigate the impact of the parking lot. Therefore, the first and most important step in implementing better site design for commercial developments *is to reduce local parking demand ratios, even if only by*

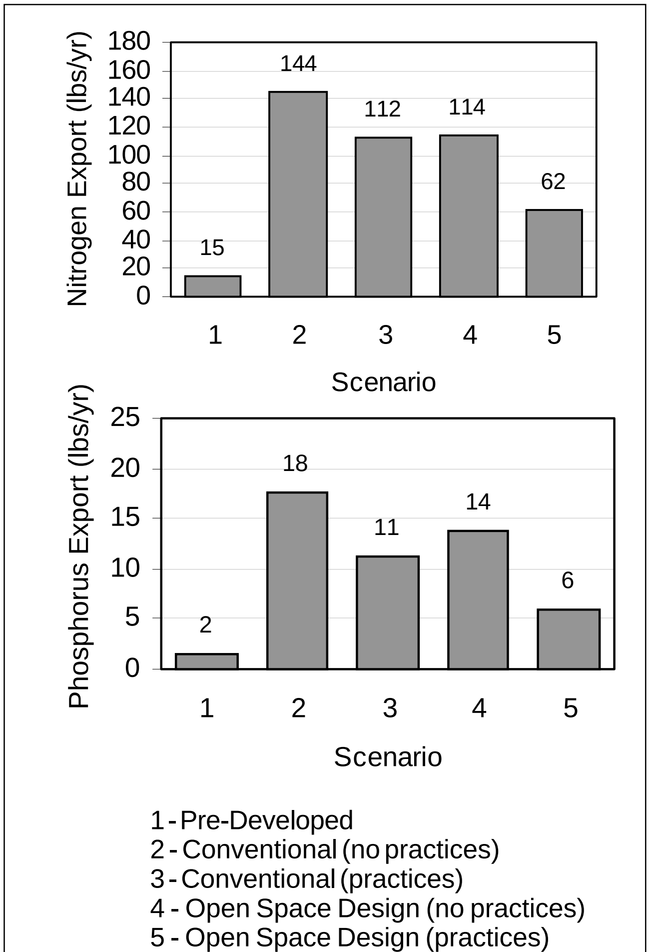

Figure 9: Annual Nitrogen and Phosphorus Load in Each 270 Corporate Office Park Development Scenario

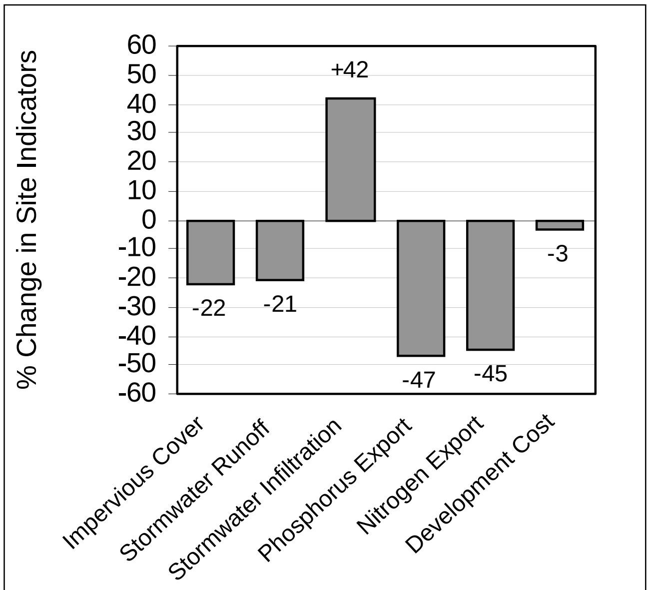

Figure 10: Percentage Change in Key Site Conditions from a Conventional Design to a Redesigned Parking lot at the 270 Corporate Office Park, Both With Stormwater Practices

five or ten percent. For many communities, however, this modest step may seem like a terrifying leap, possibly off a cliff.

Developers, bankers, retailers and drivers all have a shared interest in abundant and convenient parking, and it is hard to convince them that any attempt to downsize parking lots, however modest, will not work against this goal. This kind of thinking is quite understandable. Most people can easily recall the rare situation where parking was hard to find, but the more common situation where parking is plentiful generally escapes our everyday notice.

Small wonder, then, that so many communities are prone to inertia when it comes to changing parking codes. Perhaps the only way watershed advocates can overcome this inertia is to document the existence of excess parking capacity in each community. Indeed, it is a rather simple step for volunteers to count cars and photograph empty stalls during peak times at similar commercial land uses to demonstrate how generous local parking requirements actually are.

A small but growing list of communities are now experimenting with their parking standards and parking lot designs, including cities like Scarborough, Ontario; Oakland, CA; Olympia, WA; Sacramento, CA; Bellevue, WA; Davis, CA and Prince George's County, MD. Each community has worked in different ways to redesign their parking lots, and many of their successful experiences are recounted in *Better Site Design: A Handbook for Changing Development Rules in Your Community* (CWP, 1998a).

Given the prevalence of parking lots in our urban landscape and the environmental harm they cause, we need to fundamentally change the way that parking lots are sized and designed. The modest ideas presented in this article are merely an initial step in this direction. A wide range of professions collectively influence the form and function of parking lots, including engineers, hydrologists, landscape architects, urban foresters, soil scientists, developers, leasing agents, plan reviewers, transportation researchers and many, many others. Working together, these groups can move us closer toward the goal of a truly sustainable parking lot, i.e., one that not only provides car habitat, but also prevents damage to other habitats, as well. ***- JAZ***

References

Center for Watershed Protection. 1998a. *Better Site Design: A Handbook for Changing Development Rules in Your Community*. Site Planning Roundtable. Ellicott City, MD. 176 pp.

Center for Watershed Protection. 1998b. *Nutrient Loading From Conventional and Innovative Site Development.* Chesapeake Research Consortium. Ellicott City, MD. 56 pp.

Interlocking Concrete Pavement Institute. 2000. *Permeable Interlocking Concrete Pavements: Selection, Design, Construction and Maintenance*. Washington, DC.

Scott, Klaus I., James R. Simpson, and E. Gregory McPherson. 1999. "Effects of Tree Cover on Parking Lot Microclimate and Vehicle Emissions." *Journal of Arboriculture* 25(3):129-142.

Urban Land Institute. 1999. *Parking Requirements for Shopping Centers: Summary Recommendations and Research Study Reports*. 2nd Edition. Washington, DC. 81 pp.